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Attention, Intention, and Will in Quantum Physics *

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Abstract

How is mind related to matter? This ancient question in philosophy is rapidly becoming a core problem in science, perhaps the most important of all because it probes the essential nature of man himself. The origin of the problem is a conflict between the mechanical conception of human beings that arises from the precepts of classical physical theory and the very different idea that arises from our intuition: the former reduces each of us to an automaton, while the latter allows our thoughts to guide our actions. The dominant contemporary approaches to the problem attempt to resolve this conflict by clinging to the classical concepts, and trying to explain away our misleading intuition. But a detailed argument given here shows why, in a scientific approach to this problem, it is necessary to use the more basic principles of quantum physics, which bring the observer into the dynamics, rather than to accept classical precepts that are profoundly incorrect precisely at the crucial point of the role of human consciousness in the dynamics of human brains. Adherence to the quantum principles yields a dynamical theory of the mind/brain/body system that is in close accord with our intuitive idea of what we are. In particular, the

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need for a self-observing quantum system to pose certain questions creates a causal opening that allows mind/brain dynamics to have three distinguishable but interlocked causal processes, one micro-local, one stochastic, and the third experiential. The classical approximation reduces this tripartite quantum process to a single deterministic local process: setting Planck's constant to zero eliminates the dynamical fine structure wherein the effect of mind on matter lies.

Disclaimer

Shifting the Paradigm

A controversy is raging today about the power of our minds. Intuitively we know that our conscious thoughts can guide our actions. Yet the chief philosophies of our time proclaim, in the name of science, that we are mechanical systems governed, fundamentally, entirely by impersonal laws that operate at the level of our microscopic constituents.

The question of the nature of the relationship between conscious thoughts and physical actions is called the mind-body problem. Old as philosophy itself it was brought to its present form by the rise, during the seventeenth century, of what is called 'modern science'. The ideas of Galileo Galilei, Renê Descartes, and Isaac Newton created a magnificent edifice known as classical physical theory, which was completed by the work of James Clerk Maxwell and Albert Einstein. The central idea is that the physical universe is composed of "material" parts that are localizable in tiny regions, and that all motion of matter is completely determined by matter alone, via local universal laws. This *local* character of the laws is crucial. It means that each tiny localized part responds only to the states of its immediate neighbors: each local part "feels" or "knows about" nothing outside its immediate microscopic neighborhood. Thus the evolution of the physical universe, and of every system within the physical universe, is governed by a vast collection of local processes, each of which is 'myopic' in the sense that it 'sees' only its immediate neighbors.

The problem is that if this causal structure indeed holds then there is no need for our human feelings and knowings. These experiential qualities clearly correspond to large-scale properties of our brains. But if the entire causal process is already completely determined by the 'myopic' process postulated by classical physical theory, then there is nothing for any unified graspings of large-scale properties to do. Indeed, there is nothing that they *can* do that is not already done by the myopic processes. Our conscious thoughts thus become prisoners of impersonal microscopic processes: we are, according to this "scientific" view, mechanical robots, with a mysterious dangling appendage, a stream of conscious thoughts that can grasp large-scale properties as wholes, but exert, as a consequence of these graspings, nothing not done already by the microscopic constituents.

The enormous empirical success of classical physical theory during the eighteenth and nineteenth centuries has led many twentieth-century philosophers to believe that the problem with consciousness is how to explain it away: how to discredit our misleading intuition by identifying it as product of human confusion, rather than recognizing the physical effects of consciousness as a physical problem that needs to be answered in dynamical terms. That strategy of evasion is, to be sure, about the only course available within the strictures imposed by classical physical theory.

Detailed proposals abound for how to deal with this problem created by adoption of the classical-physics world view. The influential philosopher Daniel Dennett (1994, p.237) claims that our normal intuition about consciousness is "like a benign user illusion" or "a metaphorical by-product of the way our brains do their approximating work". Eliminative materialists such as Richard Rorty (1979) hold that mental phenomena, such as conscious experiences, simply do not exist. Proponents of the popular 'Identity Theory of Mind' grant that conscious experiences do exist, but claim each experience to be *identical* to some brain process. Epiphenomenal dualists hold that our conscious experiences do exist, and are not identical to material processes, but have no effect on anything we do: they are epiphenomenal.

Dennett (1994, p.237) described the recurring idea that pushed him to his counter-intuitive conclusion: "a brain was always going to do what it was caused to do by local mechanical disturbances." This passage lays bare the underlying presumption behind his own theorizing, and undoubtedly behind the theorizing of most non-physicists who ponder this matter, namely the presumptive essential correctness of the idea of the physical world foisted upon us by the assumptions of classical physical theory.

It has become now widely appreciated that assimilation by the general public of this "scientific" view, according to which each human being is basically a mechanical robot, is likely to have a significant and corrosive impact on the moral fabric of society. Dennett speaks of the Spectre of Creeping Exculpation: recognition of the growing tendency of people to exonerate themselves by arguing that it is not "I" who is at fault, but some mechanical process within: "my genes made me do it"; or "my high blood-sugar content made me do it." [Recall the infamous "Twinkie Defense" that got Dan White off with five years for murdering San Francisco Mayor George Moscone and Supervisor Harvey Milk.]

Steven Pinker (1997, p.55) also defends a classical-type conception of the brain, and, like Dennett, recognizes the important need to reconcile the science-based idea of causation with a rational conception of personal responsibility. His solution is to regard science and ethics as two self-contained systems: "Science and morality are separate spheres of reasoning. Only by recognizing them as separate can we have them both." And "The cloistering of scientific and moral reasoning also lies behind my recurring metaphor of the mind as machine, of people as robots." But he then decries "the doctrines of postmodernism, poststructuralism, and deconstructionism, according to which objectivity is impossible, meaning is self-contradictory, and reality is socially constructed." Yet are not the ideas he decries a product of the contradiction he embraces? Self-contradiction is a bad seed that bears relativism as its evil fruit.

The current welter of conflicting opinion about the mind-brain connection suggests that a paradigm shift is looming. But it will require a major foundational shift. For powerful thinkers have, for three centuries, been attacking this problem from every angle within the bounds defined by the precepts of classical physical theory, and no consensus has emerged.

Two related developments of great potential importance are now occurring. On the experimental side, there is an explosive proliferation of empirical studies of the relations between a subject's brain process — as revealed by instrumental probes of diverse kinds — and the experiences he reports. On the theoretical side, there is a growing group of physicists who believe almost all thinking on this issue during the past few centuries to be logically unsound, because it is based implicitly on the precepts of classical physical theory, which are now known to be fundamentally incorrect. Contemporary physical theory differs profoundly from classical physical theory precisely on the nature of the dynamical linkage between minds and physical states.

William James (1893, p.486), writing at the end of the nineteenth century, said of the scientists who would one day illuminate the mind-body problem:

"the best way in which we can facilitate their advent is to understand how great is the darkness in which we grope, and never forget that the natural-science assumptions with which we started are provisional and revisable things."

How wonderfully prescient!

It is now well known that the precepts of classical physical theory are fundamentally incorrect. Classical physical theory has been superceded by quantum theory, which reproduces all of the empirical successes of classical physical theory, and succeeds also in every known case where the predictions of classical physical theory fail. Yet even though quantum theory yields all the correct predictions of classical physical theory, its representation of the physical aspects of nature is profoundly different from that of classical physical theory. And the most essential difference concerns precisely the connection between physical states and consciousness.

My thesis here is that the difficulty with the traditional attempts to understand the mind-brain system lies primarily with the physics assumptions, and only secondarily with the philosophy: once the physics assumptions are rectified the philosophy will take care of itself. A correct understanding of the mind/matter connection cannot be based on a conception of the physical aspects of nature that is profoundly mistaken precisely at the critical point, namely the role of consciousness in the dynamics of physical systems.

Contemporary science, rationally pursued, provides an essentially new understanding of the mind/brain system. This revised understanding is in close accord with our intuitive understanding of that system: no idea of a "benign user illusion" arises, nor any counter-intuitive idea that a conscious thought is identical to a collection of tiny objects moving about in some special kind of way.

Let it be said, immediately, that this solution lies not in the invocation of quantum randomness: a significant dependence of human action on random chance would be far more destructive of any rational notion of personal responsibility than microlocal causation ever was.

The solution hinges not on quantum randomness, but rather on the dynamical effects within quantum theory of the intention and attention of the observer.

But how did physicists ever manage to bring conscious thoughts into the dynamics of physical systems? That is an interesting tale.

The World as Knowings

In his book "The creation of quantum mechanics and the Bohr- Pauli dialogue" the historian John Hendry (1984) gives a detailed account of the fierce struggles, during the first quarter of this century, by such eminent thinkers as Hilbert, Jordan, Weyl, von Neumann, Born, Einstein, Sommerfeld, Pauli, Heisenberg, Schroedinger, Dirac, Bohr and others, to come up with a rational way of comprehending the data from atomic experiments. Each man had his own bias and intuitions, but in spite of intense effort no rational comprehension was forthcoming. Finally, at the 1927 Solvay conference a group including Bohr, Heisenberg, Pauli, Dirac, and Born come into concordance on a solution that came to be called "The Copenhagen Interpretation". Hendry says: "Dirac, in discussion, insisted on the restriction of the theory's application to our knowledge of a system, and on its lack of ontological content." Hendry summarized the concordance by saying: "On this interpretation it was agreed that, as Dirac explained, the wave function represented our knowledge of the system, and the reduced wave packets our more precise knowledge after measurement."

Let there be no doubt about this key point, namely that the mathematical theory was asserted to be directly about our knowledge itself, not about some imagined-to-exist world of particles and fields.

Heisenberg (1958a): "The conception of objective reality of the elementary particles has thus evaporated not into the cloud of some obscure new reality concept but into the transparent clarity of a mathematics that represents no longer the behavior of particles but rather our knowledge of this behavior."

Heisenberg (1958b): "...the act of registration of the result in the mind of the observer. The discontinuous change in the probability function...takes place with the act of registration, because it is the discontinuous change in our knowledge in the instant of registration that has its image in the discontinuous change of the probability function."

Heisenberg (1958b:) "When the old adage 'Natura non facit saltus' is used as a basis of a criticism of quantum theory, we can reply that certainly our knowledge can change suddenly, and that this fact justifies the use of the term 'quantum jump'. "

Wigner (1961): "the laws of quantum mechanics cannot be formulated ... without recourse to the concept of consciousness."

Bohr (1934): "In our description of nature the purpose is not to disclose the real essence of phenomena but only to track down as far as possible relations between the multifold aspects of our experience."

Certainly this profound shift in physicists' conception of the basic nature of their endeavor, and the meanings of their formulas, was not a frivolous move: it was a last resort. The very idea that in order to comprehend atomic phenomena one must abandon ontology, and construe the mathematical formulas to be directly about the knowledge of human observers, rather than about the external real events themselves, is so seemingly preposterous that no group of eminent and renowned scientists would ever embrace it except as an extreme last measure. Consequently, it would be frivolous of us simply to ignore a conclusion so hard won and profound, and of such apparent direct bearing on our effort to understand the connection of our knowings to our physical actions.

This monumental shift in the thinking of scientists was an epic event in the history of human thought. Since the time of the ancient Greeks the central problem in understanding the nature of reality, and our role in it, has been the puzzling separation of nature into two seemingly very different parts, mind and matter. This had led to the divergent approaches of Idealism and Materialism. According to the precepts of Idealism our ideas, thoughts, sensations, feelings, and other experiential realities, are the only realities whose existence is certain, and they should be taken as basic. But then the enduring external structure normally imagined to be carried by matter is difficult to fathom. Materialism, on the other hand, claims that matter is basic. But if one starts with matter then it is difficult to understand how something like your experience of the redness of a red apple can be constructed out of it, or why the experiential aspect of reality should exist at all if, as classical mechanics avers, the material aspect is causally complete by itself. There seems to be no rationally coherent way to comprehend the relationship between our thoughts and the thoughtless atoms that external reality was imagined to consist of.

Einstein never accepted the Copenhagen interpretation. He said:

"What does not satisfy me, from the standpoint of principle, is its attitude toward what seems to me to be the programmatic aim of all physics: the complete description of any (individual) real situation (as it supposedly exists irrespective of any act of observation or substantiation)." (Einstein, 1951, p.667)

and

"What I dislike in this kind of argumentation is the basic positivistic attitude, which from my view is untenable, and which seems to me to come to the same thing as Berkeley's principle, esse est percipi." (Einstein, 1951,

p. 669).[Translation: To be is to be perceived]

Einstein struggled until the end of his life to get the observer's knowledge back out of physics. But he did not succeed! Rather he admitted that:

"It is my opinion that the contemporary quantum theory...constitutes an optimum formulation of the [statistical] connections." (ibid. p. 87).

He referred to:

"the most successful physical theory of our period, viz., the statistical quantum theory which, about twenty-five years ago took on a logically consistent form. ... This is the only theory at present which permits a unitary grasp of experiences concerning the quantum character of micro-mechanical events." (ibid p. 81).

One can adopt the cavalier attitude that these profound difficulties with the classical conception of nature are just some temporary retrograde aberration in the forward march of science. Or one can imagine that there is simply some strange confusion that has confounded our best minds for seven decades, and that their absurd findings should be ignored because they do not fit our intuitions. Or one can try to say that these problems concern only atoms and molecules, and not things built out of them. In this connection Einstein said:

"But the 'macroscopic' and 'microscopic' are so inter-related that it appears impracticable to give up this program [of basing physics on the 'real'] in the 'microscopic' alone." (ibid, p.674).

What Is Really Happening?

Orthodox quantum theory is pragmatic: it is a practical tool based on human knowings. It takes our experiences as basic, and judges theories on the basis of how well they work *for us*, without trying to attribute any reality to the entities of the theory, beyond the reality *for us* that they acquire from their success in allowing us to find rational order in the structure of our past experiences, and to form sound expectations about the consequences of our possible future actions.

But the opinion of many physicists, including Einstein, is that the proper task of scientists is to try to construct a rational theory of nature that is not based on so small a part of the natural world as human knowledge. John Bell opined that we physicists ought to try to do better than that.

The question thus arises as to what is 'really happening'.

Heisenberg (1958) answered this question in the following way:

"Since through the observation our knowledge of the system has changed discontinuously, its mathematical representation also has undergone the discontinuous change, and we speak of a 'quantum jump'."

"A real difficulty in understanding the interpretation occurs when one asks the famous question: But what happens 'really' in an atomic event?"

"If we want to describe what happens in an atomic event, we have to realize that the word 'happens' can apply only to the observation, not to the state of affairs between the two observations. It [the word 'happens'] applies to the physical, not the psychical act of observation, and we may say that the transition from the 'possible' to the 'actual' takes place as soon as the interaction of the object with the measuring device, and therefore with the rest of the world, has come into play; it is not connected with the act of registration of the result in the mind of the observer. The discontinuous change in the probability function, however, occurs with the act of registration, because it is the discontinuous change in our knowledge in the instant of recognition that has its image in the discontinuous change in the probability function."

This explanation uses two distinct modes of description. One is a pragmatic knowledge-based description in terms of the Copenhagen concept of the discontinuous change of the quantum-theoretic probability function at the registration of new knowledge in the mind of the observer. The other is an ontological description in terms of 'possible' and 'actual', and 'interaction of object with the measuring device'. The latter description is an informal supplement to the strict Copenhagen interpretation. I say 'informal supplement' because this ontological part is not tied into quantum theoretical formalism in any precise way. It assuages the physicists' desire for an intuitive understanding of what could be going on behind the scenes, without actually interfering with the workings of the pragmatic set of rules.

Heisenberg's transition from 'the possible' to 'the actual' at the dumb measuring device was shown to be a superfluous and needless complication by von Neumann's analysis of the quantum process of measurement (von Neumann, 1932, Chapter VI). I shall discuss that work later, but note here only the key conclusion. von Neumann introduced the measuring instruments and the body/brains of the community of human observers into the quantum state, which is quantum theory's only representation of "physical reality". He then showed that if an observer experiences the fact that, for example, 'the pointer on a measuring device has swung to the right', then this increment in the observer's knowledge can be associated exclusively with a reduction (i.e., sudden change) of the state of the brain of that observer to the part of that brain state that is compatible with his new knowledge. No change or reduction of the quantum state at the dumb measuring device is needed: no change in "knowledge" occurs there. This natural association of human "knowings" with events in human brains allows the 'rules' of the Copenhagen interpretation pertaining to "our knowledge" to be represented in a natural ontological framework. Indeed, any reduction event at the measuring device itself would, strictly speaking, disrupt in principle the validity of the predictions of quantum theory. Thus the only natural ontological place to put the reduction associated with the increases in knowledge upon which the Copenhagen interpretation is built is in the brain of the person whose knowledge is increased.

My purpose in what follows is to reconcile the insight of the founders of quantum theory, namely that the mathematical formalism of quantum theory is about our knowledge, with the demand of Einstein that basic physical theory be about nature herself. I shall achieve this reconciliation by incorporating human beings, including both their body/brains and their conscious experiences, into the quantum mechanical description of nature.

The underlying commitment here is to the basic quantum principle that information is the currency of reality, not matter: the universe is an informational structure, not a substantive one. This fact is becoming ever more clear in the empirical studies of the validity of the concepts of quantum theory in the context of complex experiments with simple combinations of correlated quantum systems, and in the related development of quantum information processing. Information-based language works beautifully, but substance-based language does not work at all..

Mind/Brain Dynamics: Why Quantum Theory Is Needed

A first question confronting a classically biased mind-brain researcher is this: How can two things so differently described and conceived as substantive matter and conscious thoughts interact in any rationally controlled and scientifically acceptable way. Within the classical framework this is impossible. Thus the usual tack has been to abandon or modify the classical conception of mind while clinging tenaciously to the "scientifically established" classical idea of matter, even in the face of knowledge that the classical idea of matter is now known by scientists to be profoundly and fundamentally mistaken, and mistaken not only on the microscopic scale, but on the scale of meters and kilometers as well (Tittel, 1998). Experiments show that our experiences of instruments cannot possibly be just the passive witnessing of macroscopic physical realities that exist and behave in the way that the ideas of classical physical theory say that macroscopic physical realities ought to exist and behave.

Scientists and philosophers intent on clinging to familiar classical concepts normally argue at this point that whereas long-range quantum effects can be exhibited under rigorous conditions of isolation and control, all quantum effects will be wiped out in warm wet brains on a very small scale, and hence classical concepts will be completely adequate to deal with the question of the relationship between our conscious thoughts and the large-scale brain activities with which they are almost certainly associated.

That argument is incorrect. The emergence of classical-type relationships arise from interactions between a system and its environment. These interactions induce correlations between this system and its environment that make certain typical quantum interference effects difficult to observe *in practice*, and that allow certain practical computations to be simplified by substituting a classical system for a quantum one. However, these correlation (decoherence) effects definitely do not entail the true emergence — even approximately — of a single classically describable system. (Zurek, 1986, p.89 and Joos, 1986, p.12). In particular, if the subsystem of interest is a brain then interactions between its parts produce a gigantic jumble of partially interfering classical-type states: no single approximately classical reality emerges. Yet if no — even-approximate — single classical reality emerges at any macroscopic scale, but only a jumble of partially interfering quantum states, then the investigation of an issue as basic as the nature of the mind-brain connection ought *in principle* to be pursued within an exact framework, rather than crippling the investigation from the outset by replacing correct principles by concepts known to be fundamentally and grossly false, just because they allow certain *practical* computations to be simplified.

This general argument is augmented by a more detailed examination of the present case. The usual argument for the approximate *pragmatic* validity of a classical conceptualization of a system is based on assumptions about the nature of the question that is put to nature. The assumption in the usual case is that this question will be about something like the position of a visible object. Then one has a clear separation of the world into its pertinent parts: the unobservable atomic subsystem, the observable features of the instrument, and unobserved features of the environment, including unobserved micro-features of the instrument. The empirical question is about the observable features of the instrument. These features are essentially just the overall position and orientation of a visible object.

But the central issue in the present context is precisely the character of the brain states that are associated with conscious experiences. It is not known a priori whether or how a self-observing quantum system separates into these various parts. It is not clear, a priori, that a self-observing brain can be separated into components analogous to observer, observee, and environment. Consequently, one cannot rationally impose prejudicial assumptions — based on pragmatic utility in simple cases in which the quantum system and measuring instrument are two distinct systems both external to the human observer, and strongly coupled to an unobservable environment — in this vastly different present case, in which the quantum system being measured, the observing instrument, and "the observer" are aspects of one unified body/brain/mind system observing itself.

In short, the practical utility of classical concepts in certain special situations arises from the very special forms of the empirical questions that are to be asked in those situations. Consequently, one must revert to the basic physical principles in this case where the special conditions of separation fail, and the nature of the questions put to nature can therefore be quite different.

The issue here is not whether distinct objects that we observe via our senses can be treated as classical objects. It is whether in the description of the complex inner workings of a thinking human brain it is justifiable to assume — not just for certain simple practical purposes, but as a matter of principle — that this brain is made up of tiny interacting parts of a kind known not to exist.

The only rational scientific way to proceed in this case of a mind/brain observing itself is to start from basic quantum theory, not from a theory that is known to be profoundly incorrect.

The vonNeumann/Wigner "orthodox" quantum formalism that I employ automatically and neatly encompasses all quantum and classical predictions, including the transition domains between them. It automatically incorporates all decoherence effects, and the partial "classicalization" effects that they engender.

vonNeumann/Wigner Quantum Theory

Wigner used the word "orthodox" to describe the formulation of quantum theory developed by von Neumann. It can be regarded as a partial ontologicalization of its predecessor, Copenhagen quantum theory.

The central concept of the Copenhagen interpretation of quantum theory, as set forth by the founders at the seminal Solvay conference of 1927, is that the basic mathematical entity of the theory, the quantum state of a system, represents "our knowledge" of the system, and the reduced state represents our more precise knowledge after measurement.

In the strict Copenhagen view, the quantum state is always the state of a limited system that does not include the instruments that we use to *prepare* that system or later to *measure* it. Our relevant experiences are those that we described as being our observations of the observable features of these instruments.

To use the theory one needs relationships between the mathematical quantities of the theory and linguistic specifications on the observable features of the instruments. These specifications are couched in the language that we use to communicate to our technically trained associates what we have done (how we have constructed our instruments, and put them in place) and what we have learned (which outcomes have appeared to us). Thus pragmatic quantum theory makes sense only when regarded as a part of a larger enveloping language that allows us describe to each other the dispositions of the instruments and ordinary objects that are relevant to the application we make. The connections between these linguistic specifications and the mathematical quantities of the theory are fixed, fundamentally, by the empirical calibrations of our instruments.

These calibration procedures do not, however, fully exploit all that we know about the atomic properties of the instruments.

That Bohr was sensitive to this deficiency, is shown by following passage:

"On closer consideration, the present formulation of quantum mechanics, in spite of its great fruitfulness, would yet seem no more than a first step in the necessary generalization of the classical mode of description, justified only by the possibility of disregarding in its domain of application the atomic structure of the measuring instruments. For a correlation of still deeper lying laws of nature ... this last assumption can no longer be maintained and we must be prepared for a ... still more radical renunciation of the usual claims of so-called visualization. (Bohr, 1936, p,293-4)"

Bohr was aware of the work in this direction by John von Neumann (1932), but believed von Neumann to be on a wrong track. Yet the opinion of many other physicists is that von Neumann made the right moves: he brought first the measuring instruments, and eventually the entire physical universe, including the human observers themselves, into the physical system represented by the quantum state. The mathematical theory allows one to do this, and it is unnatural and problematic to do otherwise: any other choice would be an artifact, and would create problems associated with an artificial separation of the unified physical system into differently described parts. This von Neumann approach, in contrast to the Copenhagen approach, allows the quantum theory to be applied both to cosmological problems, and to the mind-body problem.

Most efforts to improve upon the original Copenhagen quantum theory are based on von Neumann's formulation. That includes the present work. However, almost every other effort to modify the Copenhagen formulation aims to improve it by *removing* the consciousness of the observer from quantum theory: they seek to bring quantum theory in line with the basic philosophy of the superceded classical theory, in which consciousness is imagined to be a disconnected passive witness.

I see no rationale for this retrograde move. Why should we impose on our understanding of nature the condition that consciousness not be an integral part of it, or an unrealistic stricture of impotence that is belied by the deepest testimony of human experience, and is justified only by a theory now known to be fundamentally false, when the natural form of the superceding theory makes experience efficacious?

I follow, therefore, the von Neumann/Wigner [vN/W] formulation, in which the entire physical world is represented by a quantum mechanical state, and each thinking human being is recognized as an aspect of the total reality: each thinking human being is a body/brain/mind system, consisting of a sequence of conscious events, called knowings, bound together by the physical structure that is his body/brain.

However, the basic idea, and the basic rules, of Copenhagen quantum theory are strictly maintained: the quantum state continues to represent knowledge, and each experiential increment in knowledge, or knowing, is accompanied by a reduction of the quantum state to a form compatible with that increase in knowledge.

By keeping these connections intact one retains both the close pragmatic link between the theory and empirical knowledge, which is entailed by the quantum rules, and also the dynamical efficacy of conscious experiences, which follows from the action of the 'reduction of the quantum state' that, according to the quantum rules, is the image in the physical world of the conscious event.

In this theory, each conscious event has as its physical image not a reduction of the state of some small physical system that is external to the body/brain of the person to whom the experience belongs, as specified by the Copenhagen approach. Rather, the reduction is in that part of the state of the universe that constitutes the state of the body/brain of the person to whom the experience belongs: the reduction actualizes the pattern of activity that is sometimes called the "neural correlate" of that conscious experience. The theory thus ties in a practical way into the vast field of mind-brain research: i.e., into studies of the correlations between, on the one hand, brain activities of a subject, as measured by instrumental probes and described in physical terms, and, on the other hand, the subjective experiences, as reported by the subject, and described in the language of "folk psychology" [i.e., in terms of feelings, beliefs, desires, perceptions, and the other psychological features.]

My aim now is to show in more detail how the conscious intentions of a human being can influence the activities of his brain. To do this I must first explain the two important roles of the quantum observer.

The Two Roles of the Quantum Observer

Most readers will have heard of the Schroedinger equation: it is the quantum analog of Newton's and Maxwell's equations of motion of classical mechanics. The Schroedinger equation, like Newton's and Maxwell's equations, is deterministic: given the motion of the quantum state for all times prior to the present, the motion for all future time is fixed, insofar as the Schroedinger equation is satisfied for all times.

However, the Schroedinger equation fails when an increment of knowledge occurs: then there is a sudden jump to a 'reduced' state, which represents the new state of knowledge. This jump involves the well-known element of quantum randomness.

A superficial understanding of quantum theory might easily lead one to conclude that the entire dynamics is controlled by just the combination of the local-deterministic Schroedinger equation and the elements of quantum randomness. If that were true then our conscious experiences would again become epiphenomenal side-shows.

To see beyond this superficial appearance one must look more closely at the two roles of the observer in quantum theory.

Niels Bohr (1951, p.223), in recounting the important events at the Solvay Conference of 1927, says:

“On that occasion an interesting discussion arose also about how to speak of the appearance of phenomena for which only predictions of a statistical nature can be made. The question was whether, as regards the occurrence of individual events, we should adopt the terminology proposed by Dirac, that we have to do with a choice on the part of ‘nature’ or, as suggested by Heisenberg, we should say that we have to do with a choice on the part of the ‘observer’ constructing the measuring instruments and reading their recording.”

Bohr stressed this choice on part of the observer:

“...our possibility of handling the measuring instruments allow us only to make a choice between the different complementary types of phenomena we want to study.”

The observer in quantum theory does more than just read the recordings. He also chooses which question will be put to Nature: which aspect of nature his inquiry will probe. I call this important function of the observer ‘The Heisenberg Choice’, to contrast it with the ‘Dirac Choice’, which is the random choice on the part of Nature that Dirac emphasized.

According to quantum theory, the Dirac Choice is a choice between alternatives that are specified by the Heisenberg Choice: the observer must first specify what aspect of the system he intends to measure or probe, and then put in place an instrument that will probe that aspect.

In quantum theory it is the observer who both poses the question, and recognizes the answer. Without some way of specifying what the question is, the quantum rules will not work: the quantum process grinds to a halt.

Nature does not answer, willy-nilly, all questions: it answers only properly posed questions.

A question put to Nature must be one with a Yes-or-No answer, or a sequence of such questions. The question is never of the form “Where will object O turn out to be?”, where the possibilities range in a smooth way over a continuum of values. The question is rather of a form such as: “Will the center of object O — perhaps the pointer on some instrument — be found by the observer to lie in the interval between 6 and 7 on some specified 'dial'?"

The human observer poses such a question, which must be such that the answer Yes is experientially recognizable. Nature then delivers the answer, Yes or No. Nature's answers are asserted by quantum theory to conform to certain statistical conditions, which are determined jointly by the question posed and the form of the prior state (of the body/brain of the observer.) The observer can examine the answers that Nature gives, in a long sequence of trials with similar initial conditions, and check the statistical prediction of the theory.

This all works well at the pragmatic Copenhagen level, where the observer stands outside the quantum system, and is simply accepted for what he empirically is and does. But what happens when we pass to the vN/W ontology? The observer then no longer stands outside the quantum system: he becomes a dynamical body/brain/mind system that is an integral dynamical part of the quantum universe.

The basic problem that originally forced the founders of quantum theory to bring the human observers into the theory was that the evolution of the state via the Schroedinger equation does not fix or specify where and when the question is posed, or what the question actually is. This problem was resolved by placing this issue in the hands and mind of the external human observer.

Putting the observer inside the system does not, by itself, resolve this basic problem: the Schroedinger evolution alone remains unable to specify what the question is. Indeed, this bringing of the human observer into the quantum system intensifies the problem, because there is no longer the option of shifting the problem away, to some outside agent. Rather, the problem is brought to a head, because the human agent is precisely the quantum system that is under investigation.

In the Copenhagen formulation the Heisenberg choice was made by the mind of the external human observer. I call this process of choosing the question the Heisenberg process. In the vN/W formulation this choice is not made by the local deterministic Schroedinger process and the global stochastic Dirac process. So there is still an essential need for a third process, the Heisenberg process. Thus the agent's mind can continue to play its key role. But the mind of the human agent is now an integral part of the dynamical body/brain/mind. We therefore have, now, an intrinsically more complex dynamical situation, one in which a person's conscious thoughts can — and evidently must, if no new element is brought in, — play a role that is not reducible to the combination of the Schroedinger and Dirac processes. In an evolving human brain governed by ionic concentrations and electric-magnetic field gradients, and other continuous field-like properties, rather than sharply defined properties, or discrete well-defined "branches" of the wave function, the problem of specifying, within this amorphous and diffusive context, the well-defined question that is put to nature is quite nontrivial.

Having thus identified this logical opening for efficacious human mental action, I now proceed to fill in the details of how it might work.

How Conscious Thoughts Could Influence Brain Process

Information is the currency of reality. That is the basic message of quantum theory.

The basic unit of information is the "bit": the answer 'Yes' or 'No' to some specific question.

In quantum theory the answer 'Yes' to a posed question is associated with an operator P that depends on the question. The defining property of a projection operator is that P squared equals P: asking the very same question twice it is the same as asking it once. The operator associated with the answer 'No' to this same question is $1 - P$. Note that $(1 - P)$ is also a projection operator: $(1 - P)^2 = 1 - 2P + P^2 = 1 - 2P + P = (1 - P)$.

To understand the meaning of these operators P and $(1 - P)$ it is helpful to imagine a trivial classical example. Suppose a motionless classical heavy point-like particle is known to be in a box that is otherwise empty. Suppose a certain probability function F represents all that you know about the location of this particle. Suppose you then send some light through the left half of the box that will detect the particle if it is in the left half of the box, but not tell you anything about where in the left half of the box the particle lies. Suppose, moreover, that the position of the particle is undisturbed by this observation. Then let P be the operator that acting on any function f sets that function to zero in the right half of the box, but leaves it unchanged in the left half of the box. Note that two applications of P has exactly the same effect as one application, $P^2 = P$. The question put to nature by your probing experiment is: "Do you now know that particle is in the left half of the box? Then the function PF represents, apart from an overall normalization factor, your new state of knowledge if the answer to the posed question was YES. Likewise, the function (1-P)F represents, apart from overall normalization, the new probability function, if the answer was NO.

The quantum counterpart of F is the operator S. Operators are like functions that do not commute: the order in which you apply them matters. The analog of $PF \equiv PFP$ is PSP, and the analog of $(1-P)F \equiv (1-P)F(1-P)$ is $(1-P)S(1-P)$.

This is how the quantum state represents information and knowledge, and how increments in knowledge affect the quantum state.

I have described in my book (Stapp, 1993, Ch 6) my conception of how the quantum mind/brain works. It rests on some ideas/findings of William James.

William James(1910, p.1062) says that:

"a discrete composition is what actually obtains in our perceptual experience. We either perceive nothing, or something that is there in sensible amount. This fact is what in psychology is known as the law of the 'threshold'. Either your experience is of no content, of no change, or it is of a perceptual amount of content or change. Your acquaintance with reality grows literally by buds or drops of perception. Intellectually and on reflection you can divide these into components, but as immediately given they come totally or not at all."

This wholeness of each perceptual experience is a main conclusion, and theme, of Jamesian psychology. It fits neatly with the quantum ontology.

Given a well posed question about the world to which one's attention is directed quantum theory says that nature either gives the affirmative answer, in which case there occurs an experience describable as "Yes, I perceive it!" or, alternatively, no experience occurs in connection with that question.

In vN/W theory the 'Yes' answer is represented by a projection operator P that acts on the degrees of freedom of the brain of the observer, and reduces the state of this brain — and also the state S of the universe — to one compatible with that answer 'Yes': S is reduced to PSP. If the answer is 'No', then the projection operator $(1 - P)$ is applied to the state S: S is reduced to (1-P)S(1-P). [See Stapp (1998b) for technical details.]

James (1890, p.257) asserts that each conscious experience, though it comes to us whole, has a sequence of temporal components ordered in accordance with the ordering in which they have entered into one's stream of conscious experiences. These components are like the columns in a marching band: at each viewing only a subset of the columns is in front of the viewing stand. At a later viewing a new column has appeared on one end, and one has disappeared at the other. (cf. Stapp, 1993, p. 158.) It is this possibility of having a sequence of different components present in a single thought that allows conscious analysis and comparisons to be made.

Infants soon grasp the concept of their bodies in interaction with a world of persisting objects about them. This suggests that the brain of an alert person normally contains a "neural" representation of the current state of his body and the world about him. I assume that such a representation exists, and call it the body-world schema. (Stapp, 1993, Ch. 6)

Consciously directed action is achieved, according to this theory, by means of a 'projected' (into the future) temporal component of the thought, and of the body-world schema actualized by the thought: the intended action is represented in this projected component as a mental image of the intended action, and as a corresponding representation in the brain, (i.e., in a body-world schema) of that intended action. The neural activities that automatically flow from the associated body-world schema tend to bring the intended bodily action into being.

The coherence and directedness of a person's stream of consciousness is maintained, according to this theory, because the instructions effectively issued to the unconscious processes of the brain by the natural dynamical unfolding that issues from the actualized body-world schema include not only the instructions for the initiation or continuation of motor actions but also instructions for the initiation or continuation of mental processing. This means that the actualization associated with one thought leads physically to the emergence of the propensities for the occurrence of the next thought, or of later thoughts. (Stapp, 1993, Ch. 6)

The idea here is that the action — on the state S — of the projection operator P that is associated with a thought T will actualize a pattern of brain activity that will dynamically evolve in such a way as to tend to create a subsequent state that is likely to achieve the intention of the thought T. The natural cause of this positive correlation between the experiential intention of the thought T and the matching confirmatory experience of a succeeding thought T' is presumably set in place during the formation of brain structure, in the course of the person's interaction with his environment, by the reinforcement of brain structures that result in empirically successful pairings between experienced intentions and subsequently experienced perceptions. These can be physically compared because both are expressed physically by similar body-world schemas.

As noted previously, the patterns of brain activity that are actualized by an event unfold not only into instructions to the motor cortex to institute intended motor actions. They unfold also into instructions for the creation of the conditions for the next experiential event. But the Heisenberg uncertainties in, for example, the locations of the atomic and ionic constituents of the nerve terminals, and more generally of the entire brain, necessarily engender a quantum diffusion in the evolving state of the brain. Thus the dynamically generated state that is the pre-condition for the next event will not correspond exactly to a well defined unique question: some 'scatter' will invariably creep in. However, a specific question must be posed in order for the next quantum event to occur!

This problem of how to specify "the next question" is the central problem in most attempts to 'improve' the Copenhagen interpretation by excluding "the observer". If one eliminates the observer, then something else must be brought in to fix the next question: i.e., to make the Heisenberg choice.

The main idea here is to continue to allow the question to be posed by the 'observer', who is now an integral part of the quantum system: the observer is a body/brain/mind subsystem. The Heisenberg Choice, which is the choice of an operator P that acts macroscopically, as a unit, on the observing system, is not fixed by the Schroedinger equation, or by the Dirac Choice, so it is most naturally fixed by the experiential part of that system, which seems to pertain to macroscopic aspects of brain activity taken as units.

Each experience is asserted to have an intentional aspect, which is its experiential goal or aim, and an attentional aspect, which is an experiential focussing on an updating of the current status of the person's idea of his body, mind, and environment.

When an action is initiated by some thought, part of the instruction is normally to monitor, by attention, the ensuing action, in order to check it against the intended action.

In order for the appropriate experiential check to occur, *the appropriate question must be asked.* The intended action is formulated in experiential terms, and the appropriate monitoring question is whether this intended experience matches the subsequently occurring experience. *This connection has the form of the transference of an experience defined by the intentional aspect of an earlier experience into the experiential question attended to — i.e., posed — by a later experience.*

This way of closing the causal gap associated with the Heisenberg Choice introduces two parallel lines of causal connection in the body/brain/mind system. On the one hand, there is the physical line that unfolds — under the control of the local deterministic Schroedinger equation — from a prior event, and that generates the physical *potentialities* for succeeding possible events. Acting in parallel to this physical line of causation, there is a mental line of causation that transfers the experiential intention of an earlier event into an experiential attention of a later event. These two causal strands, one physical and one mental, join to form the physical and mental poles of a succeeding quantum event.

In this model there are three intertwined factors in the causal structure: (1), the local causal structure generated by the Schroedinger equation; (2), the Heisenberg Choices, which is based on the experiential aspects of the body/brain/mind subsystem that constitutes a person; and (3), the Dirac Choices on the part of nature.

The point of all this is that there is within the vN/W ontology a logical necessity, in order for the quantum process to proceed, for *some process* to fix the Heisenberg Choice of the operator P, which acts over an extended portion of the body/brain of the person. Neither the Schroedinger evolution nor the Dirac stochastic choice can do the job. The only other known aspect of the system is our conscious experience. It is possible, and natural, to use this mind part of body/brain/mind system to produce the needed choice.

The mere logical possibility of a mind-matter interaction such as this, within the vN/W formulation, indicates that quantum theory has the potential of permitting the experiential aspects of reality to enter into the causal structure of body/brain/mind dynamics, and to enter in a way that is not fully reducible to a combination of local mechanical causation specified by the Schroedinger equation and the random quantum choices. The requirements of quantum dynamics *demand* some further process, and an experienced-based process that fits both our ideas about our psychological make up and also the quantum rules that connect our experiences to the informational structure carried by the evolving physical state of the brain seems to be the perfect candidate.

What has been achieved here is, of course, just a working out in more detail of Wigner's idea that quantum theory, in the von Neumann form, allows for mind — pure conscious experience — to *interact* with the 'physical' aspect of nature, as that aspect is represented in quantum theory. What permits this interaction is the fact that the physical aspect of nature, as it is represented in quantum theory, is informational in character, and hence links naturally to increments in knowledge. Because each increment in knowledge acts directly upon the quantum state, and reduces it to the informational structure compatible with the new knowledge, there is, right from the outset, an action of mind on the physical world. I have just worked out a possible scenario in more detail, and in particular have emphasized how the causal gap associated with the Heisenberg Choice allows mind to enter into the dynamics in a way that is quite in line with our intuition about the efficacy of our thoughts. It is therefore simply wrong to proclaim that the findings of science entail that our intuitions about the nature of our thoughts are necessarily illusory or false. Rather, it is completely in line with contemporary science to hold our thoughts to be causally efficacious, and reducible neither to the local deterministic Schroedinger process, nor to that process combined with stochastic Dirac choices on the part of nature.

Idealism, Materialism, and Quantum Informationism.

I have stressed just now the idea-like character of the physical state of the universe, within vN/W quantum theory. This suggests that the theory may conform to the tenets of idealism. This is partially true. The quantum state undergoes, when a fact become fixed in a local region, a sudden jump that extends over vast reaches of space. This gives the physical state the character of a representation of knowledge rather than a representation of substantive matter. When not jumping the state represents potentialities or probabilities for actual events to occur. Potentialities and probabilities are normally conceived to be idea-like qualities, not material realities. So as regards the intuitive conception of the intrinsic nature of *what is represented* within the theory by the physical state it certainly is correct to say that it is idea-like.

On the other hand, the physical state has a mathematical structure, and a behaviour that is governed by the mathematical properies. It evolves much of the time in accordance with local deterministic laws that are direct quantum counterparts of the local deterministic laws of classical mechanics. Thus as regards various structural and causal properties the physical state certainly has aspects that we normally associate with matter.

So this vN/W quantum conception of nature ends up having both idea-like and matter-like qualities. The causal law involves two complementary modes of evolution that, at least at the present level theoretical development, are quite distinct. One of these modes involves a gradual change that is governed by local deterministic laws, and hence is matter-like in character. The other mode is abrupt, and is idea-like in *two* respects.

This hybrid ontology can be called an information-based reality. Each answer, Yes or No, to a quantum question is one bit of information that is generated by a mental-type event. The physical repository of this information is the quantum state of the universe: the new information is recorded as a reduction of the quantum state of the universe to a new form, which then evolves deterministically in accordance with the Schroedinger equation. Thus, according to this quantum conception of nature, the physical universe — represented by the quantum state — is a repository of evolving information that has the dispositional power to create more information.

This hybrid ontology can be called an information-based reality. Each answer. Yes or No, to a quantum question is one bit of information that is generated by a mental-type event. This event is registered as a reduction of the quantum state of the universe to a new form. This information is stored in this state, which evolves deterministically in accordance with the Schroedinger equation. Thus, according to the quantum conception, the physical universe — represented by the quantum state — is a repository evolving information that has the dispositional power to create more information.

Quantum Zeno Effect and The Efficacy of Mind

In the model described above the specifically mental effects are expressed solely through the choice and the timings of the questions posed. The question then arises as to whether just the choices about which questions are asked, with no control over which answers are returned, can influence the dynamical evolution of a system.

The answer is 'Yes': the evolution of a quantum state can be greatly influenced by the choices and timings of the questions put to nature.

The most striking example of this is the Quantum Zeno Effect. (Chui, Sudarshan, and Misra, 1977, and Itano, et al. 1990). In quantum theory if one poses repeatedly, in very rapid succession, the same Yes-or-No question, and the answer to the first of these posings is Yes, then in the limit of very rapid-fire posings the evolution will be confined to the subspace in which the answer is Yes: the effective Hamiltonian will change from H to PHP, where P is the projection operator onto the Yes states. This means that evolution of the system is effectively "boxed in" in the subspace where the answer continues to be Yes, if the question is posed sufficiently rapidly, even if it would otherwise run away from that region.

This fact that the Hamiltonian is effectively changed in this macroscopic way shows that the choices and timings of which questions are asked can affect observable properties.

Free Will and Causation

Personal responsibility is not reconciled with the quantum understanding of causation by making our thoughts *free*, in the sense of being completely unconstrained by anything at all. It is solved, rather, by making our thoughts *part* of the causal structure of the body/brain/mind system, but a part that is not under the complete dominion of myopic (*i.e., microlocal*) causation and random chance. Our thoughts then become aspects of the causal structure that are *entwined* with the micro-physical and random elements, yet are not completely reducible to them, or replaceable by them.

Pragmatic Theory of the Mind/Brain

This vN/W theory gives a conceivable ontology. However, for practical purposes it can be viewed as a pragmatic theory of the human psycho-physical structure. It is deeper and more realistic than the Copenhagen version because it links our thoughts not directly to objects (instruments) in the external world, but rather to patterns of brain activity. It provides a theoretical structure based explicitly on the two kinds of data at our disposal, namely the experiences of the subject, as he describes these experiences to himself and his colleagues, and the experiences of the observers of that subject, as they describe their experiences to themselves and their colleagues. These two kinds of descriptions are linked together by a theoretical structure that neatly, precisely, and automatically accounts, in a single uniform and practical way, for all known quantum and classical effects. But, in contrast to the classical-physics based model, it has a ready-made place for an efficacious mind, and provides a rational understanding of how such a mind could be causally enmeshed with brain processes.

If one adopts this pragmatic view then one need never consider the question of nonhuman minds: the theory then covers, by definition, the science that we human beings create to account for the structure of our human experiences.

This pragmatic theory should provide satisfactory basis for a rational science of the human mind/brain. It gives a structure that coherently combines the psychological and physical aspect of human behavior. However, it cannot be expected to be exactly true, for it would entail the existence of collapse events associated with increments in human knowledge, but no analogous events associated with non-humans.

One cannot expect our species to play such a special role in nature. So this human-based pragmatic version must be understood, from the ontological standpoint, as merely the first stage in the development of a better ontological theory: one that accommodates the evolutionary precursors to the human knowings that the pragmatic theory is based upon.

So far there is no known empirical evidence for the existence of any reduction events not associated with human knowings. This impedes, naturally, the development of a science that encompasses such other events.

Future Developments: Representation and Replication

The primary purpose of this paper has been to describe the general features of a pragmatic theory of the human mind/brain that allows our thoughts to be causally efficacious yet not controlled by local-mechanistic laws combined with random chance. Eventually, however, one would like to expand this pragmatic version into a satisfactory ontology theory.

Human experiences are closely connected to human brains. Hence events similar to human experiences would presumably not exist either in primitive life forms, or before life began. Hence a more general theory that could deal with the *evolution of consciousness* would presumably have to be based on something other than the "experiential increments in knowledge" that were the basis of the pragmatic version described above.

Dennett (1994, p.236) identified intentionality (aboutness) as a phenomenon more fundamental than consciousness, upon which he would build his theory of consciousness. 'Aboutness' pertains to representation: the representation of one thing in another.

The body-world schema is the brain's representation of the body and its environment. Thus it constitutes, in the theory of consciousness described above, an element of "aboutness" that could be seized upon as the basis of a more general theory.

However, there lies at the base of the quantum model described above an even more rudimentary element: self-replication. The basic process in the model is the creation of events that create likenesses of themselves. This tendency of thoughts to create likenesses of themselves, helps to keep a train of thought on track.

Abstracting from our specific model of human consciousness one sees the skeleton of a general process of self-replication.

Fundamentally, the theory described above is a theory of events, where each event has an *attentional* aspect and an *intentional* aspect. The attentional aspect of an event specifies an item of information that fixes the operator P associated with that event. The intentional aspect of the event specifies the functional property injected into the dynamics by the action of P on S. This functional property is a tendency of the Schroedinger-directed dynamics to produce a future event whose attentional aspect is the same as that of the event that is producing this tendency. The effect of these interlocking processes is to inject into the dynamics a directional tendency, based on approximate self-replication, that acts against the chaotic diffusive tendency generated by the Schroedinger equation. Such a process could occur before the advent of our species, and of life itself, and it could contribute to their emergence.

Conflation and Identity

A person's thoughts and ideas appear — to that person himself — to be able to do things: a person's mental states seem to be able cause his body to move about in intended ways. Thus thoughts seem to have functional power. Indeed, the idea of *functionalism* is that what makes thoughts and other mental states what they are is precisely their functional power: e.g., my pain is a pain by virtue of its functional or causal relationship to other aspects of the body/brain/mind system. Of course, this would be merely a formal definition of the term “mental state” if it did not correspond to the occurrence of an associated element in a person’s stream of consciousness: in the context of the present study — of the connection between our brains and our inner experiential lives — the occurrence of a mental state in a person’s mind is supposed to mean the occurrence of a corresponding element in his stream of consciousness.

The identity theory of mind claims that each mental state is *identical* to some process in a brain. But combining this idea with the classical-physics conception of the physical universe leads to problems. They stem from the fact that the precepts of classical physical theory entail that the entire causal structure of any complex physical system is completely determined by its microscopic physical structure alone. Alternative high-level descriptions of certain complex physical systems might be far more useful to us in practice, but they are in principle redundant and unnecessary if the principles of classical physics hold. Thus it is accurate to say that the heat of the flame caused the paper to ignite, or that the tornado ripped the roofs off of the houses and left a path of destruction. But according to the precepts of classical physical theory the high-level causes are mere mathematical reorganizations of microscopic causes that are completely explainable micro-locally within classical physical theory. Nothing is needed beyond mathematical reorganization and — in order for us to be able to apply the theory — the assumption that we can empirically know, through observations via our senses,the approximate relative locations and shapes of sufficiently large macroscopically localized assemblies of the microscopic physical elements that the theory posits.

In the examples just described our experiences themselves are not the causes of the ignition or destruction: our experiences merely help us to identify the causes. In fact, the idea behind classical physical theory is that the local physical variables of the theory represent a collection of ontologically distinct physical realities each of whose ontological status is (1), intrinsically microlocal, (2), ontologically independent of our experiences, and (3), dynamically non-dependent upon experiences. That is why quantum theory was such a radical break with tradition: in quantum theory the physical description became enmeshed with our experiential knowledge, and the physical state became causally dependent upon our mental states.

Quantum theory is, in this respect, somewhat similar to the identity theory of mind: both entangle mind and physical process already at the ontological level. But the idea of the classical identity theory of the mind is to hang onto the classical conception of physical reality, and aver that a correct understanding of the true nature of a conscious thought would reveal it to be none other than a classically describable physical process that brings about what the thought intends, given the appropriate alignment of the relevant physical mechanisms.

That idea is, in fact, what would naturally emerge from quantum theory in the classical limit where the difference between Planck's constant and zero can be ignored, and the positions of particles and their conjugate momentum can both be regarded as well defined, relative to any question that is posed. In that limit there is no effective quantum dispersion caused by the Heisenberg uncertainty principle, and hence no indeterminism, and the only Heisenberg Choices of questions about a future state that can get an answer 'Yes' are those that are in accord with the functional properties of the present state. So there would be, in that classical approximation to the quantum process described above, a collapse of the two lines of causation, the physical and the mental, into a single one that is fixed by the local classical deterministic rules. Thus in the classical approximation the mental process would indeed be doing nothing beyond what the classical physical process is already doing, and the two process might seem to be the same process. But Planck's constant is not zero, and the difference from zero introduces quantum effects that separate the two lines of causation, and allow their different causal roles to be distinguished.

The identity theory of mind raises puzzles. Why, in a world composed primarily of ontologically independent micro-realities, each able to access or know only things in its immediate microscopic environment, and each completely determined by micro-causal connections from its past, should there be ontological realities such as conscious thoughts that can grasp or know, as wholes, aspects of huge macroscopic collections of these micro-realities, and that can have intentions pertaining to the future development of these macroscopic aspects, when that future development is already completely fixed, micro-locally, by micro-realities in the past?

The quantum treatment discloses that these puzzles arise from the conflation in the classical limit of two very different but interlocked causal processes, one micro-causal, bound by the past, and blind to the future, the other macro-causal, probing the present, and projecting to the future.

Mental Force and the Volitional Brain

The psychiatrist Jeffrey Schwartz (1999) has described a clinically successful technique for treating patients with obsessive compulsive disorder (OCD). The treatment is based on a program that trains the patient to believe that his own *willful redirection* of his attention away from intense urges of a kind associated with pathological activity within circuitry of the basal ganglia, and toward adaptive functional behaviours, can, with sufficient persistent effort, systematically change both the intrusive, maladaptive, obsessive-compulsive symptoms, as well as the pathological brain activity associated with them. This treatment is in line with the quantum mechanical understanding of mind/brain dynamics developed above, in which the mental/experiential component of the causal structure enters brain dynamics via intentions that govern attentions that influence brain activity.

According to classical physical theory "a brain was always going to do what it was caused to do by local mechanical disturbances," and the idea that one's "will", is actually able to cause anything at all is "a benign user illusion". Thus Schwartz's treatment amounts, according to this classical conceptualization, to deluding the patient into believing a lie: according to that classical view Schwartz's intense therapy causes directly, in the patients behaviour, a mechanical shift that the patient delusionally believes is the result of his own *intense effort* to redirect his activities, for the purpose of effecting an eventual cure, but which (felt effort) is actually only a mysterious illusionary by-product of his altered behaviour.

The presumption about the mind/brain that is the basis of Schwartz's successful clinical treatment, and the training of his patients, is that willful redirection of attention is efficacious. His success does not prove that 'will' is efficacious, but it does constitute prima facie evidence that it is. In fact, the belief that our thoughts can influence our actions is so basic to our entire idea of ourselves and our place in nature, and is so essential to our actual functioning in this world, that any suggestion that this idea is false would become plausible only under extremely coercive conditions, such as its incompatibility with basic physics. But no such coercion exists. Contemporary physical theory does allow our experiences, per se, to be truly efficacious and non-reducible: our experiences are elements of the causal structure that do necessary things that nothing else in the theory can do. Thus science, if pursued with sufficient care, demands no cloistering of disciplines, or interpretation as user illusions of the apparent causal effects of our conscious thoughts upon our physical actions.

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